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Author(s)	OKAMOTO, Yoshifumi; YAMADA, Kinya; NOZAKI, AKIHIKO; OGAWA, HIROKI; WATANABE, YUTAKA
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Complete Dehiscence of Sternum after Cardiac Surgery

Yoshifumi OKAMOTO, and Kinya YAMADA
The 1st Department of Surgery, Shimane Medical University
AKIHIKO NOZAKI, HIROKI OGAWA and YUTAKA WATANABE
Surgical Department of Ohtsu Red Cross Hospital

Median sternotomy is a simple surgical procedure for exposing the heart and large vessels both rapidly and over an adequately wide area. At present this approach is employed for almost all operations on the heart utilizing a heart-lung machine.

There are few complications of median sternotomy. Complete dehiscence of the sternum rarely occur as a serious complication, however.

The mediastinum undergoes a change in shape under physiological conditions, e. g., with the position of the body or respiration. The pressure within the mediatinum is lower than the atmospheric pressure and differs between inspiration and expiration.

Inflammation, once extending to the mediastinum, readily spreads over the entire structure, leading to a serious condition with copious discharge of blood and pus.

Cardiotomy involves the use of foreign materials, such as prosthetic valves and vessels and Teflon fabric, with an aortocoronary bypass and myocardial sutures lying bare in the mediastinum. Infection, if transmitted by such a prosthesis or material, is highly dangerous[1].

Four cases of postoperative dehiscence of the sternum are illustrated below.

Operative technique

With the patient supine, the skin is incised along the midline from the upper end of the sternum to the epigastrium. The subcutaneous tissue and the sternal periosteum are incised by use of diathermy. Bleeding from the subcutaneous tissue is completely arrested by cauterization. The sterum is cut longitudinally with the oscillating stryker bone saw. Scissors with straight blades are used in infants.

The xiphoid should be resected since necrotic cartilagineous remains prolong eventual wound-infections. Bleeding from the periosteum is carefully stopped by using diathermy.

Key Words : Median sternotomy, Dehiscence of sternum, Foreign materials, Mediastinitis, Mediastinal irrigation.
索引語：胸骨正中切開，胸骨裂開，生体内異物，縦隔炎，縦隔洗じょう.
Present address : The first Department of Surgery, Shimane Medical University, Izumo, Shimane, 693, Japan.

Bone-wax is applied for the purpose of suppressing the bleeding in the spongiosa of the sternum. Precautions must be exercised against bone fracture, which is thereby caused frequently in aged patients.

On closure of the wound, a drain is placed substernally in the upper chest and in the pericardium. The pericardium is often left unsutured. To achieve stable adaptation of the sternum monofile stainless steel wires are used, No. 22 wire at 3 sites in children and No. 24 wire at 3 or 4 sites in adults. The drain is usually withdrawn after 24-48 hours.

Report of Cases

Case 1——A 48-year-old man with stenotic left coronary artery and myocardial infarction underwent a coronary bypass operation under extracorporeal circulation utilizing Kolobow membrane lung. Cardiac operation was performed after producing cardiac arrest by topical cooling with Ringer's solution.

Discharge through the drain placed in the thoracic cavity continued postoperatively. On the 5th day of affection cardiac tamponade and then cardiac arrest developed, necessitating emergent re-opening of the wound with closed-chest cardiac massage.

The thoracic cavity and mediastinum were washed after removing a large quantity of blood clot and fibrin collecting in lump there. On the 12 th day, sternal dehiscence occurred.

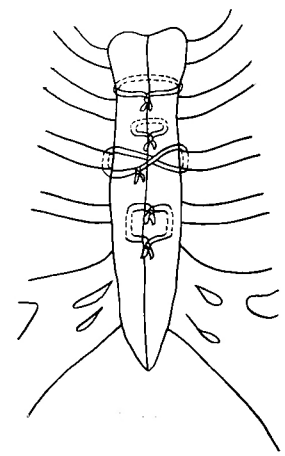

Fig. 1. Several techniques of sternal closure.

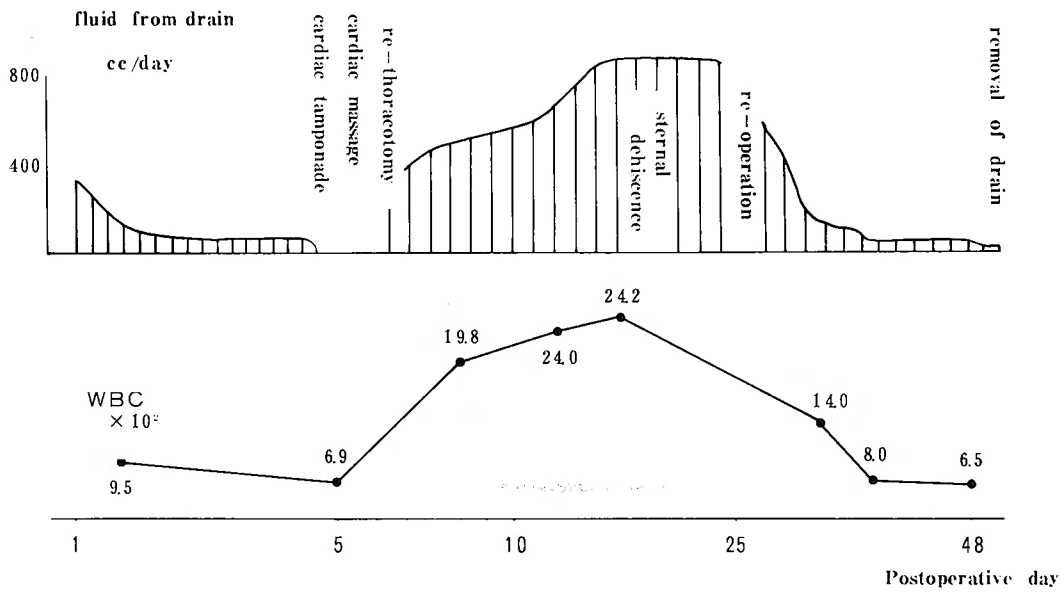

Fig. 2. Postoperative course of Case 1.

The sternum was found split horizontally by the wire. It was very difficult to restore the integrity of the sternum. Closure of the wound was made barely feasible by using a number of wires to fix the sternum in U-shape as shown at the bottom of Fig. 1.

Examination of the pus revealed Staphylococcus epidermidis as the causative organism. The mediastinum was persistently irrigated with a cephalosporin in saline.

Withdrawal of the drain in the thoracic cavity became permissible on the 48th day. Fig. 2.

Case 2——A 52-year-old woman underwent aortic and mitral valve replacement with topical cooling of the heart under extracorporeal circulation. A respirator was used from immediately after operation onward. Tracheotomy was performed on the 5th day of affection. On the 9th day dyspnea developed and the sternum became dehiscent and mobile with increased pus discharge, persistent high fever and exposure of the heart. Blood cultures showed bacterial growth. These changes culminated in death of the patient on the 13th postoperative day. The causative organism was Pseudomonas aeruginosa.

Case 3——A 40-year-old man with mitral stenosis and cerebral infarction underwent cardiotomy for the second time after a time interval of 13 years. Mitral valve replacement and plication of the tricuspid annulus were performed by means of local cooling of the heart with Ringer's solution using an artificial lung with Kolobow membrane.

Massive bleeding occurred because of an anticoagulant treatment having been used just until the day before operation and because of surgical isolation being achieved with difficulty this time. Postoperative discharge was also voluminous. Withdrawal of the intrathoracic drain became feasible on the 6th day of affection. On the 8th day of affection the sternum was found dehiscent, and on the 13th day there was complete dehiscence of the sternum despite the use of a bust band. Immediately closure of the wound was performed. The sternum was so fragile as to provide no site for fixation with wire, nor permit even figure-of-eight suture. Immobilization of the sternum was with a number of steel wires fixed by means of holes made by drilling the ribs across the costicartilage (Fig. 3). The subcutaneous tissue was sutured with Ti-cron 1-0 to help in immobilization.

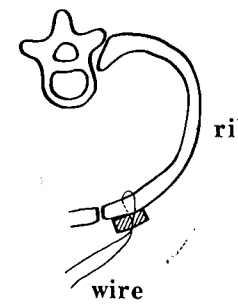

Fig. 3. The sternum was fixed with steel wires drilling the ribs across the costicartilage.

The causative organism was Serratia marcescens, which was resistant to cephalosporin. Tobracin in saline was used to irrigate the pleural cavity and mediastinum continuously. On the 23rd day it became possible to withdraw the drain.

Case 4——A 12-year-old boy underwent correction for tetralogy of Fallot. At the time of complete repair, he had acquired atretic pulmonary artery. Continuity between the right ventricle and the pulmonary artery was established with a Hancock valved external conduit. He required one day of mechanical ventilatory support but otherwise had an uncomplicated postoperative course. He had persistent serous drainage from the chest tube for several

Table1. Clinical data

Cace No.	Age, Sex	Diagnosis	Operation	Results
1	48yr M	Coronary artery disease	Aortocoronary bypass	survived
2	52yr F	Aortic and Mitral insufficiency	Aortic and Mitral valve replacement	Died
3	40yr M	Mitral stenosis	Mitral valve replacement and tricuspid annuloplication	survived
4	12yr M	Tetralogy of Fallot	Reconstruction with external valved conduit	Died

days. But, 7 days after operation, with the rise of the temperature to 40°C, prulent drainage appeared from the lower end of the sternotomy incision. The sternal wound partially dehisced and instability was treated conservatively with chest wall binders. Cultures of the pus from mediastinal drainage grew Serratia marcescens. He had received massive amounts of antibiotic agents. But, blood cultures showed bacterial growth same as from drainage. He became septic, with temperature spikes of 39.0° to 40.5°C and white blood cell count consistently above 18,000 cells per cubic millimeter with a marked shift to the left. In the morning on the 15th postoperative day, with massive bleeding from mediastinum, complete dehiscence of the sternum occurred. Emergency operation was performed which showed rupture at the suture line of distal portion of the prosthetic conduit. He died from the septic shock.

Causes and Prevention

Dehiscence of the sternum can be prevented by immobilizing it properly and controlling infection.

OCHSNER[8] et al. classified 20 cases of dehiscence of the sternum according to the presence or absence of complicating bacterial infection. Dehiscence occurred without infection in the largest proportion or 12 of these cases. Dehiscence was followed by infection in 5 cases while it was secondary to bacterial infection in 3 cases. The cause of dehiscence was a supposedly improper procedure of incision or closure of the wound in 9, postoperative external cardiac massage in 2, prolonged use of the respirator in 4, re-thoracotomy in 2 and infection alone in 3 cases. STONEY[10] et al., on the other hand, stated that inadequate fixation of the sternum was responsible for its dehiscence in all cases, bacterial infection being secondary in nature.

The causes of sternal dehiscence in our series include re-opening of the wound due to cardiac tamponade, decreased cardiac output, external cardiac massage, tracheotomy and prolonged use of a positive-pressure respirator.

Fixation of the sternum: Satisfactory fixation of the sternum appears to be essential for the prevention of its dehiscence. In median sternotomy care must be taken to cut the sternum in the midline from the manubrium to the gladiolus. A thoracotomy lateral retractor

should be such in shape and used in such a way as will not cause multiple fractures. Prolonged postoperative use of a respirator or external cardiac massage in cases of emergency many make the sternum unstable and mobile.

In adults or aged persons, 6-8 steel wires should be used to ensure that the cut surfaces of the sternum are in close contact with each other. The manubrium which is particularly tough should be fixed with 2 wires. In cases of the sternum undergoing fracture or cut not in the midline, figure-of-eight suture involving ribs may be used to ensure fixation[2]. A bust band is used postoperatively to assist in reinforcing the firmness of the sternum in cases of failing apposition of its cut surfaces, in cases where fracture of the sternum may occur as in aged patients, or in uncommon cases of rarefaction of bone associated with Marfan's syndrome.

Infection: In Case 2 dehiscence of the sternum with bacterial infection made it impossible to perform reoperation in time, with resultant sepsis leading to death of the patient. Cardiotomy may be expected to involve the risk of bacterial contamination, since, unlike other surgical procedurs, it extends over a long period of time, requiring exposure of the circulatory system and the use of a heart-lung machine[4].

Prophylactic use of antibiotics of major importance[5]. Senility, hypoproteinemia, metabolic defects, and administration of immunosuppressants such as adrenocortical hormones are the factors which make the patient susceptible to infection. A propensity to heart failure present preoperatively also is likely to lead to a serious postoperative complication.

In addition, the complicated pathophysiologic situation involving extracorporeal circulation may reduce the defensive ability of the body against infection.

The use of heparin during the surgery makes it indispensable to take adequate hemostatic measures. On the other hand, too much use of electrocoagulation is inadvisable because of extensive necrosis of tissue. Bleeding from bone marrow during sternotomy may be controlled by using bone wax, a foreign material just like steel wires for fixation of the sternum. The number of the latter material used for this purpose was intentionally reduced to 3 or 4, but has been increased to 6-8 on the ground that resultant inadequate fixation is accountable for dehiscence of the sternum in adults.

Suture materials have much to do with wound infection through tissue reactions. The use of Ti-cron thread for suturing subcutaneous fascia and the like has made suture infection less frequent. Re-operation required for the control of bleeding or cardiac tamponade has a close relation to the development of mediastinal infection or dehiscence of the sternum. There is an increased hazard of contamination when opening of the wound is emergently necessitated. Despite a meticulous hemostatic procedure, re-thoracotomy may become necessary because of thrombocytopenia ensuing in diseases manifested by cyanosis, prothrombin deficiency due to hepatic dysfunction in right heart failure, or a defect in factor Ⅴ or Ⅷ, thrombocytopenia and fibrinolysis during extracorporeal circulation.

Contamination of the tracheostomy also is very likely to lead to mediastinitis. Tracheotomy should be done as late as possible, or incision of the lower trachea should be avoided.

The operative field is difficult to disinfect by brushing or other means. Bacterial flora

Table 2. Organism isolated

Case No.	Organism
1	Staphylococcus epidermidis
2	Pseudomonas aeruginosa
3	Serratia marcescens
4	Serratia marcescens

gaining entrance to the depth of the skin provides a source of contamination for the wound surface, being not subject to bactericidal action. Our experience shows that sternal dehiscence has resulted from the use of Ringer's solution for topical cooling of the heart as a means of protecting it during cardiotomy. It is hence probable that the solution moistened the skin and wound surface, thereby making them liable to contamination. The wound surface should be covered with water-proof fabric. Other predisposing factors include pulmonary infections and wound infections.

In recent years there has been a marked increase in the incidence of postoparative infection with gram-negative organisms, notably Pseudomonas aeruginosa or Serratia marcescens. Opportunistic pathogens resistant to various antibiotics have come into question. Nasu[7] et al. stated that nonpathogenic organisms including Serratia marcescens are likely to be responsible for infection of wounds communicating with the outer envionment. The mediastinum exposed with blood and pus through the chest tube provides a source of infection with such organisms. The drainage tubes should be removed as early as possible.

Treatment

The sternum, once it has undergone complete dehiscence, is impossible to fix by ordinary means, such as immobilization with plastic bandage, wearing of a bust band or the technique of traction. It is now necessary to achieve fixation surgically to keep the thorax from being mobile.

The sternum is split into pieces by steel wires previously placed. Its structure also is so fragile as to permit only unsatisfactory fixation. For these reasons figure-of-eight suture involving the costicartilage is often infeasible. Lead buttresses or metal plates have been used as a support to steel wires in such situations[7][8][9].

A number of steel wires are used for fixation at the very site where tension is best tolerated. In Case 3 the rib beyond the costicartilage served as such. For mediastinal drainage two drains are used, one for infusion and the other for discharge, so that adequate mediastinal irrigation is ensured postoperatively[10][11]. Stitches of No. 1 Ti-cron suture are densely put in the fascia, which is edematous, to help in fixing the sternum.

After closure of the wound, the sternum so fixed is further reinforced by using a bust band or chest

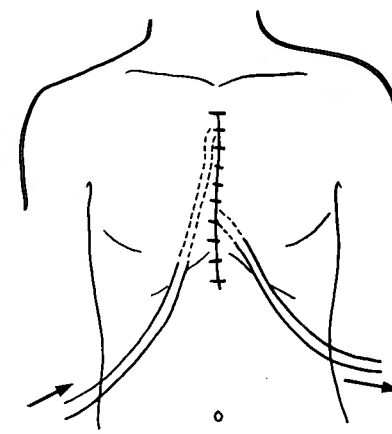

Fig. 4. Two mediastinal tubes are in place. The left tube is being used for infusion, the other for drainage.

wall tractor. Postoperatively, mediastinal irrigation is carried out intermittently or, if possible, continuously. (Fig. 4) The fluid used for purpose contains a selected antibiotic in saline, an antibiotic which is appropriate for the causative organism identified. A cephalosporin was used with success in Case 1 and Tobracin in Case 3.

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和文抄録

開心手術後の胸骨完全裂開

島根医科大学第1外科学教室

岡 本 好 史，山 田 公 彌

大津赤十字病院外科

野崎 昭彦，小川 博暉，渡辺 裕

胸骨正中切開法に伴う合併症は少ないが，重篤なものとして胸骨完全裂開がある．開心手術では，人工弁，人工血管，テフロン布などの異物を生体内に使用し，また冠動脈バイパス，心筋縫合糸等が縦隔で露出している故感染を合併すればその危険性はきわめて大きくなる．

胸骨完全裂開4症例に検討を加えた．2例は敗血症で失ったが，2例は再閉創，縦隔持続洗じようにより治癒せしめた．

胸骨裂開は，適切な胸骨固定と感染防止により予防できる．とりわけ胸骨固定を確実にすることは必須の処置と思われる．